

Appendix i.

DEVONIAN FORAMINIFERA : TAMWORTH DISTRICT, NEW SOUTH WALES.

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(Plates xxxix.-xli.)

Introduction.

At the request of Dr. W. N. Benson, B.A., F.G.S., I am giving the details of foraminiferal evidence which I noticed whilst examining some micro-sections of limestone from the Nemingha horizon of the Tamworth Series. The method of studying foraminifera from rock-slices, without accompanying specimens showing the exterior of the test, is not entirely satisfactory, but the fact that these organisms are of Devonian age is, in itself, of sufficient importance to merit a record of the occurrence, foraminifera being extremely rare in Devonian faunas.

The Rock-structure and its Stratigraphical Association.

The foraminifera under notice occur in a well-developed oolitic limestone in which granules form a little more than half the bulk of the rock. The granules vary in diameter from 0.46 to 0.7 mm., and only a small proportion are entirely due to oolitic accretion; whether originally of algal origin or not it is impossible to say, on account of their present mineralised condition. The nucleus of the oolite-grain in more than one case was seen to consist of an ossicle of a crinoid. The majority of the grains, however, are microgranulitic in structure, either in the nucleus, or more rarely throughout the entire granule. Certain of these, from their more irregular outline, and often without an external coat of concentric oolitic deposit, led me to suspect their foraminiferal relationship, which conclusion is borne out by further study of the specimens. Some of the perfectly spherical grains

are, I feel convinced, of a radiolarian nature, and here and there one can detect a central sphere. There is a fair amount of iron-staining in the rock-structure, which seems to be entirely secondary, as the stain is developed more strongly along incipient fracture-lines than in the grains themselves.

From Dr. Benson's work on the rocks of the Tamworth District,* it is seen that the Nemingha horizon can be correlated with the lower part of the Middle Devonian.

Previous Records of Devonian Foraminifera.

In turning to consider the occurrence of foraminifera in other parts of the world, we find only one authentic record of these minute fossils, viz., that of Terquem's, who figured and described a few forms from the Middle Devonian of Paffrath in the Eifel.† On p.417 of Terquem's note, he states that the foraminifera were found in some sand contained in a *Megalodon*-shell. They were in the condition of casts. The material was probably referable to foraminifera and ostracoda, but generally indeterminable. Some spheres covered with thick and sharply pointed spines he referred to *Orbulina*. These were very common, and measured 0.48 mm. in diameter. A pyriform cast was referred to *Lagenulina* (a subgenus of *Lagena*). A cristellarian was also noticed by Terquem, presenting the arrangement of chambers seen in *Cristellaria vetusta* from the Lias. A fusiform cast was compared to *Fusulina*; and numerous globular casts, consisting of two or three chambers, were identified as *Globigerina*. Judging from my own observations of radiolarian structures in the Devonian of Silesia and Bavaria, I am inclined to think that Terquem's prickly *Orbulinæ* may have more than a fancied relationship to the orbicular radiolarians. In connection with the present work, I have recently examined some disintegrated limestone from Paffrath, from shells in the National Museum, and

* "The Geology and Petrology of the Great Serpentine Belt of New South Wales. Part v. The Geology of the Tamworth District." Proc. Linn. Soc. N. S. Wales, 1915, Vol. xl., Pt.3, pp.540-624, Pls. xlix.-lviii.

† Terquem, O.—"Observation sur quelques fossiles des epoques primaires." Bull. Soc. Geol. France, ser.3, Vol. viii., 1880, pp.414-418, Pl. xi.

have succeeded in finding a small but representative series of foraminifera, radiolaria, and ostracoda which I hope to describe shortly.

The only other allusion to Devonian foraminifera that I have so far come across, is that by E. Wethered, in his paper on the limestones of South Devon.* In speaking of the organic constituents of the *Goniatite* limestone (Upper Devonian) from a quarry at Whiteway Farm, near Chudleigh, Mr. Wethered says—"The specimens collected as typical of this limestone show it to be quite different in structure from the beds below. There is a fine crystalline groundmass in which are several fragmentary remains of organisms. One of these appears to be a foraminifer, and it is especially interesting as being the only one found in my slides of the South Devon limestones. The *Goniatite* limestone seems to have been formed by an accumulation of small shells, foraminifera, etc., which have been filled in with a fine calcareous mud." Wethered does not, however, refer the foraminifer he saw to any particular genus.

Description of the Foraminifera.

Fam. ASTORRHIZIDÆ.

Subfam. SACCAMMININÆ.

Genus PSAMMOSPHERA Schulze.

PSAMMOSPHERA NEMINGHENSIS, n.sp. (Plates xxxix, figs.1-2; xl, fig.10; xli., figs.11-12).

Description.—Test rudely spherical to elongate flask-shape. Wall composed of granular particles neatly fitted together, forming one or two layers, and distinct from the large crystalline grains of the matrix more or less completely infilling the cavity of the test. Apertures apparently between the components of the test-wall or, more rarely, as a slight protuberance on the surface.

Diameter, circ. 0·4 to 0·75 mm.

Observations.—The above form has a certain resemblance to

* "On the Microscopic Structure and Residues Insoluble in Hydrochloric Acid in the Devonian Limestones of South Devon." Quart. Journ. Geol. Soc., Vol. xlviii., 1892, pp.377-387.

Saccamina, but it never has the orifice so strongly protuberant. *Psammospheera*, as a genus, has not been found in fossil deposits older than the Jurassic, from which system Dr. Haeusler* has recorded the living species *P. fusca* Schulze. The present species is less than half the size of the Jurassic and recent forms.

P. neminghensis is by far the commonest foraminifer in the Nemingha limestone, representing about 90 per cent. of the entire foraminiferal remains.

Fam. TEXTULARIIDÆ.

Genus VALVULINA d'Orbigny.

VALVULINA PLICATA, Brady. (Plate xxxix., figs. 3, 4).

Valvulina plicata Brady, 1873, Mem. Geol. Surv. Scotland, Expl. Sheet 23, pp. 66, 95, etc.; Idem, Pal. Soc. Mon., Vol. xxx., 1876, p. 88, Pl. iv., figs. 10, 11. Chapman, 1907, "Notes on Fossils from the Collie Coal-field," Bull. Geol. Surv. W. Austr., No. 27, p. 16, Pl. ii., figs. 10a-c.

Observations.—Several specimens occur in the microscope-slides, which compare closely with Brady's species from the Lower and Upper Carboniferous Limestone of England and Scotland, as well as in the *Fusulina*-beds (Carboniferous) of Iowa, U.S.A. The writer has described a diminutive specimen of the above species from the Carbopermian Sandstone associated with *Glossopteris* leaves from Collie, W. Australia.

An example occurs in one of the slides, which indicates a plastogamic union of two individuals, as frequently seen in *Discorbina*, *Vaginulina*, and other genera.

VALVULINA BULLOIDES Brady. (Plate xxxix., figs. 5, 6, 7).

Valvulina bulloides Brady, 1876, Pal. Soc. Mon., Vol. xxx., p. 89, Pl. iv., figs. 12-15. Chapman and Howchin, 1905, "Mon. Foram. Permo-Carboniferous Limestones of N. S. Wales," Mem. Geol. Surv. N. S. Wales, Pal., No. 14, p. 13, Pl. i., figs. 9a-c.

Observations.—This species closely resembles a high and tumid *Globigerina*, but is easily distinguished by the open umbilical cavity on the lower surface, and the valvuline aperture.

* Quart. Journ. Geol. Soc., Vol. xxxix., 1883, p. 26, Pl. ii., fig. 1.

V. bulloides was previously confined to the Carboniferous and Carbopermian. Dr. H. B. Brady records from the *Fusulina*-beds of the Upper Coal-Measures of North America, the Calcaire de Namur of Belgium, and the *Fusulina*-Limestone of Miatschkovo, near Moscow. The same species was described by Mr. Howchin and the writer from the Carbopermian limestone (Branxton Stage of the Upper Marine Series), of Wollongong, N. S. Wales.

Not uncommon in the Nemingha Limestone.

VALVULINA OBLONGA, sp.nov. (Plate xl., fig.8).

Description.—Several examples of an elongated valvuline type occur in the slides. They remind one of a short, stout *Haplophragmium*, or the *Lituola nautiloidea* Lam., figured by Dr. Brady from the Carboniferous of Northumberland,* but show the depressed base and characteristic aperture of these Devonian and Carboniferous modifications of *Valvulina*.

The longer diameter of a fairly complete specimen in section is 1 mm.; the shorter diameter, 0.65 mm.

PULVINULINA BENSONI, sp.nov. (Plate xl., fig.9).

Description.—This species differs from the majority of the test-sections in the micro-slides of the Nemingha limestone in having a finely granulate shell-wall, which may, at one time, have been of hyaline structure. The section figured shows a certain amount of depth, although sliced, and indicates a pulvinuline type of shell with few, lobulate chambers, and a wavy, peripheral margin. It was probably depressed on the superior face, and slightly conoidal on the inferior.

The nearest Palæozoic form to this seems to be *P. broeckijana* Brady,† from the Carboniferous Limestone of Namur, Belgium, but differs essentially in its rounder outline and less inflated chambers. It belongs to the *Pulvinulina elegans* group, and, from its size and contour, indicates a shallow-water variant of that type of shell.

* Pal. Soc. Mon., Vol. xxx., 1876, p.63, Pl. viii., figs.7a, b.

† Pal. Soc. Mon., Vol. xxx., 1876, p.140, Pl. vi., figs.12a-c.

Summary.

The components of the Nemingha limestone appear to be largely foraminiferal, comprising, so far as the evidence from microscope rock-sections shows, an abundant species of *Psammosphæra* — *P. neminghensis*; and the following more or less sparsely represented — *Valvulina plicata* Brady, *V. bulloides* Brady, and *V. oblonga*, sp.nov.; whilst *Pulvinulina* appears to be present in *P. bensoni*, sp.nov.

The genus *Psammosphæra* is more at home in deep rather than in shallow water, though it has been found in depths as little as 45 fathoms. The other genera indicate a fairly shallow-water habitat.

One special point of interest stands out conspicuously in the foraminifera of this limestone, viz., the rather strong resemblance of the rare Devonian foraminiferal fauna to the Carboniferous and higher beds of the Palæozoic.

Radiolaria seem to form a considerable proportion of the granules in the Nemingha limestone, but their mineralised condition precludes any reference to definite genera.

As regards the probable depth at which the rock was formed, one might reasonably assume it to be of moderately deep water origin from the occurrence of *Psammosphæra* and the radiolarians. On the other hand, oolitic grains are indicative of quite shallow-water areas, though this latter constituent is by no means predominant, and may not materially affect the above conclusion. The general condition of deposition must have been such as would obtain in a moderately deep inland gulf with quiet sedimentation and accumulation of ooze-forming organisms; and it is just possible that the oolite-grains may have been blown into the area of deposition from dunes of shore-sand origin in the vicinity.

In conclusion, I would tender my sincere thanks to Dr. Benson for giving me the opportunity of examining this interesting limestone, and facilitating this attempt to describe a unique faunula by furnishing the microscope preparations.

EXPLANATION OF PLATES XXXIX.-XLI.

Plate xxxix.

Fig. 1.—*Psammosphæra neminghensis*, sp. nov. Section through test showing shell-wall and introverted aperture.

Fig. 2.—*P. neminghensis*, sp. nov. Section showing interior thickened with secondary calcitic deposit.

Fig. 3.—*Valulina plicata* Brady. Section through and a little above the base.

Fig. 4.—*V. plicata* Brady. Two tests, probably in plastogamic union.

Fig. 5.—*V. bulloides* Brady. Flattened and almost complete test.

Fig. 6.—*V. bulloides* Brady. Median section.

Fig. 7.—*V. bulloides* Brady. Nearly complete test.

All figures magnified 52 diams.

Plate xl.

Fig. 8.—*Valulina oblonga*, sp. nov. Basal section; ($\times 52$).

Fig. 9.—*Pulvinulina beasoni*, sp. nov. Almost complete test; ($\times 52$).

Fig. 10.—Section through *Psammosphæra neminghensis*, showing relative thickness of test; ($\times 144$).

Plate xli.

Fig. 11.—Section of Nemingha limestone with oolite-grains, *Psammosphæra*, and (?)radiolarian; ($\times 28$).

Fig. 12.—Ditto, with oolite-grains and *Psammosphæra*; ($\times 28$).